Fermi National Accelerator Laboratory

A Department of Energy National Laboratory Managed by Fermi Research Alliance, LLC

Functional Requirements Specifications

Muon Campus Delivery Ring AIP

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Fermilab

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B. Introduction

The Delivery Ring AIP will convert the former Antiproton Debuncher ring into a Delivery Ring for beam to the Muon Campus. The Delivery Ring will support beam operations for the Mu2e and Muon g-2 experiments. For Mu2e operation, protons of 8-GeV kinetic energy from the Recycler will be stored and resonantly extracted to the Mu2e production target, and protons remaining after resonant extraction will be kicked into an abort. For g-2 operation, secondary pions and protons as well as tertiary decay muons from the g-2 production target will be transported through the Delivery Ring, the protons will be kicked into an abort, and the remaining beam of muons will be extracted towards the g-2 storage ring.

C. Project Scope

The Delivery Ring AIP will provide an injection system consisting of a C-magnet, magnetic septum, and kickers to support Muon Campus operation. Both beam line elements and power sources for these devices are provided. Additionally, an abort system consisting of kickers, septum, and beam line magnets will direct beam to an in tunnel absorber that is also provided by the AIP. Many components from the Tevatron Collider run will be modified and repurposed for these systems.

The Delivery Ring AIP will also upgrade the electrical infrastructure and floor space in the AP10 and AP30 service buildings to support the new equipment required by the Muon Campus Projects. This upgrade includes functional power panels needed for the new systems, and cable tray needed to supply the input AC power to that equipment.

The Beam Position Monitor system will be modified to be used with the required beam structure and repetition rate. Beam Loss Monitor suitable for use with beam intensities up to 1 E12 protons/pulse will be installed. Collider equipment that is not needed for Muon operation, and would be a limiting aperture will be removed by the AIP. The control system links and cooling water system will be modified to allow construction of the new external beam line enclosure.

D. Requirements

a. Store and support resonant extraction of 8-GeV protons for Mu2e

- Mu2e operation requires a machine admittance of 35 π mm-mrad.
- The injection and abort systems must be capable of 8.9 GeV/c transfers at intervals of 59 msec with an average rate of 6 Hz.
- Protons will be stored while beam is resonantly extracted towards the Mu2e target.
- The beam abort system will be used to remove the protons that do not get extracted every Mu2e cycle. The abort dump will be capable of handling an average beam power of 640 Watts which is equivalent to 5 e11 protons/sec at 8.9 GeV/c.
- A beam loss monitor system will be provided that will be capable of detecting a local loss of .01 R/sec, and not saturate below 100 R/sec.
- A beam position monitoring system will be provided that will be able to measure beam position of a single bunch with a bunch length of 120 nsec, and intensities as low as 5 e9. Both closed orbit and turn by turn capabilities will be provided by this system.
- An extraction system and RF systems will not be provided by this AIP.

b. Transport 3-GeV secondary beam for g-2

- The Delivery Ring aperture will provide for 40 π-mm-mrad (un-normalized) acceptance.
- The pulsed power supply systems will allow 3.1 GeV secondaries to be transferred at an average rate of 12 Hz, and with a burst of beam pulses separated by as little as 10 msec.
- The ability to circulate beam between 0 and 10 revolutions before extraction to the g-2 storage ring.

- A system will be provided to remove protons from the beam to be extracted provided at least 4 revolutions in the Delivery Ring are made.
- An extraction system is not provided by this AIP

c. The Delivery Ring will operate with an average vacuum of 1 e-8 torr or better;
d. The Delivery Ring is expected to operate for 8 years with an estimated shutdown period of one month every year;
e. Delivery Ring components are subject to compliance with FESHM;
f. All of the components and subsystems will be manufactured using Fermilab QA procedures and standards.